# Vegetated Infiltration Swale (1005)

# Swales can be Swell when Designed Properly

*Post-Construction Stormwater Management Workshops*

*November - December 2004*

WISCONSIN DEPT. OF NATURAL RESOURCES

# Status of Standard

**Standard is currently going through a final review and will be posted on the web-site as an interim standard once completed.**

**Post-Construction**
**Storm Water Management**

| STANDARD | Number | File Size (KB) | Effective Date | Tech Notes |
|---|---|---|---|---|
| Bioretention for Infiltration (includes drawings in Zip file) | 1004 | 881 | 10/04 | available |
| Compost | S100 | 90 | 10/04 | |
| Infiltration Basin (includes drawings in Zip file) | 1003 | 901 | 10/04 | available |
| Infiltration Trench | | | | |
| Rain Gardens | | | | |
| Site Evaluation for Stormwater Infiltration | 1002 | 183 | 02/04 | |
| Swales | | | | |
| Wet Detention Pond | 1001 | 27 | 09/99 | |

Technical Standards are created via the Standards Oversight Council (SOC) process. The SOC is an organization charged with working through the inherent difficulties of coordinating the needs of diverse interests and overseeing the development, maintenance and distribution of quality technical standards for conservation practices in Wisconsin.

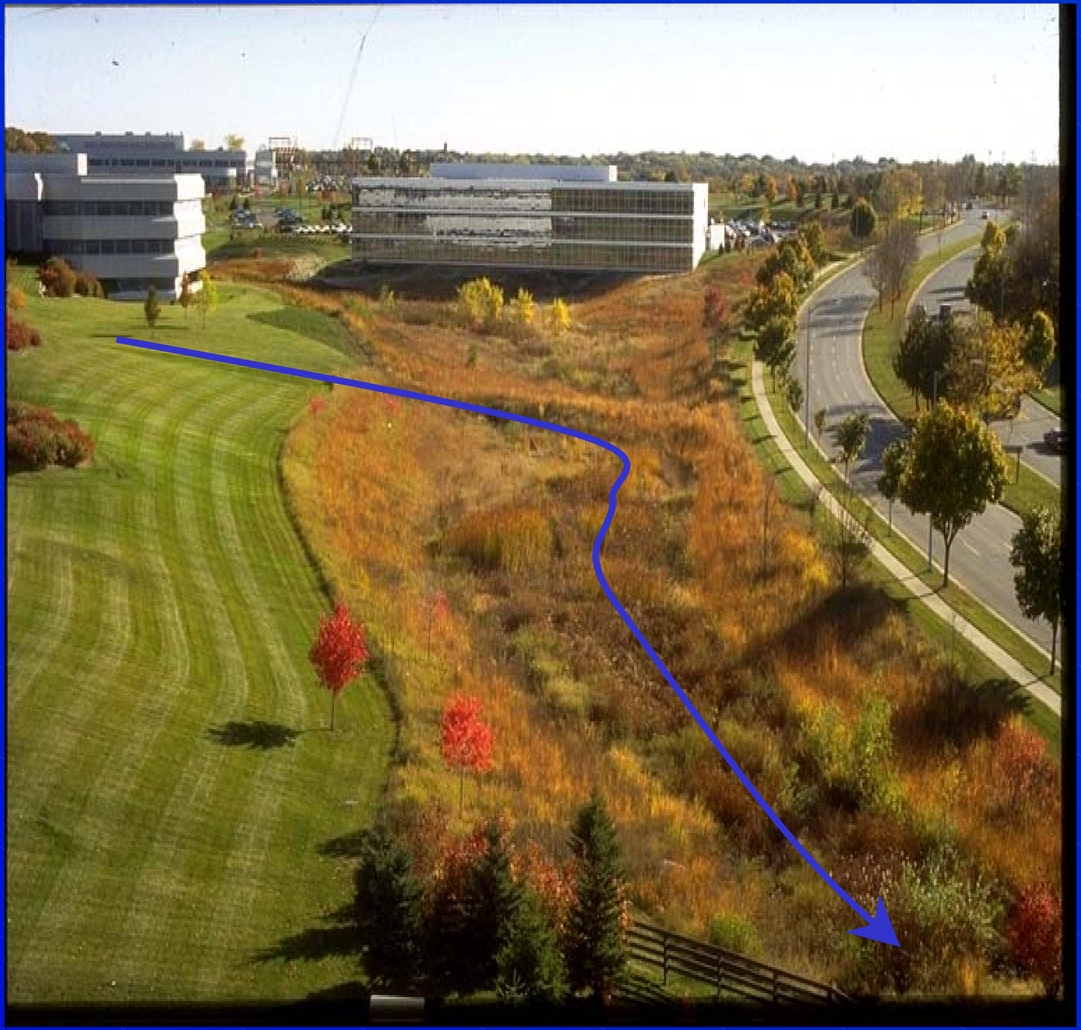
# Definition and Purpose

- Differs from a conventional conveyance or filtration swale in that it is designed specifically to promote infiltration.

- Vegetated to help filter pollutants and enhance and maintain the soil’s infiltration capacity.

# Definition and Purpose

Is interchangeable with an infiltration basin (1003) or bioretention basin (1004) but a swale is longer than it is wide and also acts as a conveyance device.



# Best Applications of Swales

- Best suited for low- to medium-density residential land uses.
- Placed along roads or other linear features.

# NR 151 Effective Infiltration Area

- In order to be counted toward the cap the swale must:
  - Meet criteria outlined in standard (1005).
  - Receive treated runoff or runoff from areas not required to meet pre-treatment requirements outlined in NR 151 (low to medium density residential land uses).

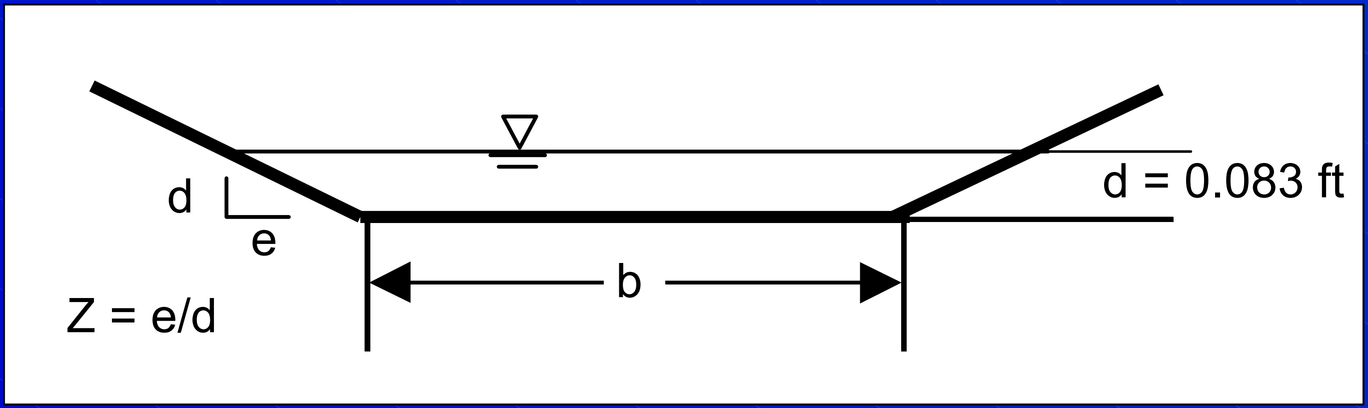
# Potential Pre-treatment Options

- Filter strips
- Vegetated filtering swales
- Detention Basins

# NR 151 Effective Infiltration Area

NR 151 Effective Infiltration Area ($ft^2$) =
1/2 * wetted perimeter (ft) * Swale Length (ft)

Wetted perimeter is calculated at 1-inch depth of flow to account for small frequent storms



# Design Infiltration Rate

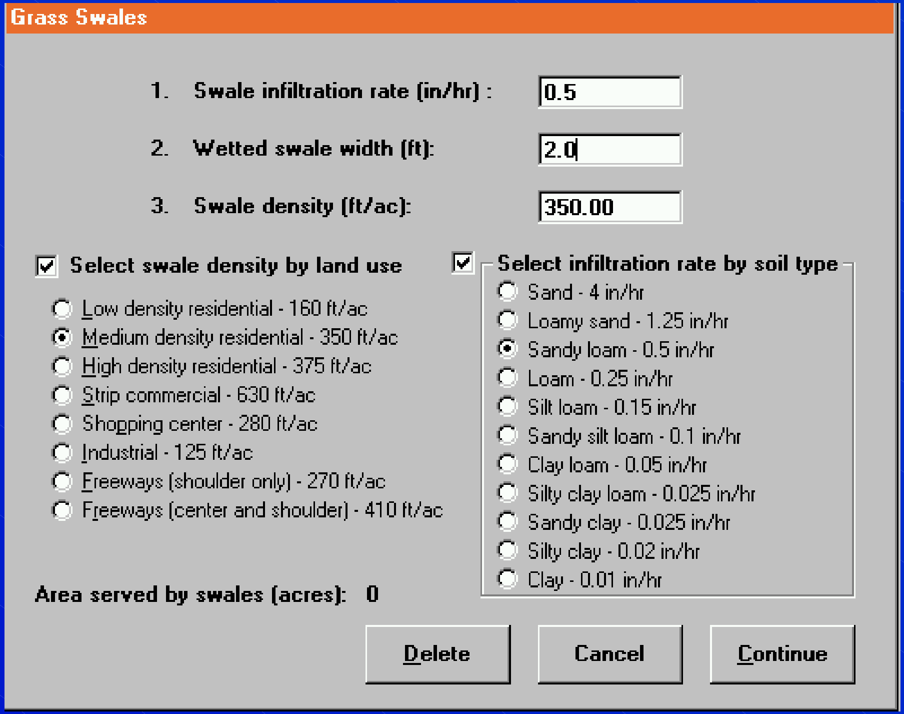
The infiltration rate used for swale design shall be ½ the rate for the appropriate soil listed or calculated in DNR Standard 1002.

$$K_{swale}\ (\text{inches /hr}) = \tfrac{1}{2}\ K_{Static}$$

*Reference: Wanielista, et al., 1983*

# Calculation of Infiltration Volume

- Shall be determined by an approved model.
  - SLAMM, P-8, or manual method...
- Use applicable average annual time-series rather than design storm approach for better integration into overall management plan.



# Calculation of Infiltration Volume

- Currently both SLAMM and P-8 assume:
  - sheet flow / shallow depth of flow maintained (P-8 assumes trapezoidal geometry)
  - longitudinal slopes ranging between 1 and 4%
  - Swales are designed in compliance with standard design
  - swale length long enough to allow adequate residence time

- No dynamic routing (Muskingum or kinimatic method)

- SLAMM used an assigned static wetted perimeter, however, new version varies WP for storm events based on weighted flow using a modified triangular hydrograph. P-8 varies WP based on hourly flow rates.

# Calculation of Infiltration Volume

## Current Method in SLAMM allows for Manual computation

**% Volume Reduction = (Pr/Rr)*(As/At)**

where:

- Pr = percolation volume rate
- Rr = runoff rate to swale
- As = Area served by swale
- At = Total study area

Note: Pr/Rr less than or equal to 1 (can’t infiltrate more than there is runoff, if calculated greater than 1 then set to 1)

*Source: SLAMM user Manual*

# Calculation of Infiltration Volume

**% Volume Reduction = (Pr/Rr)*(As/At)**

where:

Pr / Rr = ratio of infiltration volume to runoff volume

Volume Infiltrated = Runoff Volume * (Pr/Rr)

As/At = weights the infiltration volume reduction based on what infiltrated for the contributory area compared to the runoff from the entire project site

*Source: SLAMM user Manual*

# Calculation of Infiltration Volume

## Example:

Contributory volume of runoff = 1140 $ft^3$

Duration of Rain Event = 5.5 hours

Dynamic Percolation rate = 0.25 in/hr *(1/2 static rate from 1002 Std.)*

Swale density = 350 ft/acre

Wetted swale width (WP) = 5 feet

Contributory area to swales = 1.5 acres

Total drainage area of site = 3.3 acres

1) Calculate runoff duration:

duration = 0.90 + 0.98 (rain duration) *(Pitt, 1987)*

6.29 hours = 0.90 + 0.98 (5.5 hours)

# Calculation of Infiltration Volume

2) Calculate average runoff rate:

Rr = contributory area runoff volume / runoff duration

$Rr = 1140\ ft^3 / 6.29 = 181\ ft^3/hr = 0.05\ ft^3/sec$

3) Calculate percolation (infiltration) volume rate:

$Pr = K_{swale}$ * swale density * contributory area * WP

Pr = (0.25 in/hr) * (350 ft/acre) * (1.5 acres) * (5 ft) * (hr/3600 sec) * (ft/12 in) = $0.015\ ft^3/sec$

4) Calculate Infiltration volume for contributory area:

Infiltration volume (ft3) = runoff volume * (Pr/Rr)

Infiltration volume = $1140\ ft^3$ * (0.015 / 0.05) = **$\underline{342\ ft^3}$**

# Calculation of Infiltration Volume

5) Computed weighted average over entire site (SLAMM method):

**% Volume Reduction = (Pr/Rr)*(As/At)**

**% Volume Reduction =** (0.015 / 0.05) * (1.5 / 3.3 ) = 0.136 = 14%

Alternative method is to calculate % reduction for entire project site is to compare the ratio of infiltration volume to total project site runoff.

# Summary of Design Criteria

| | |
|---|---|
| Bottom Width | Shape dependent: 2-feet min., 6-feet max. for trapezoidal and parabolic |
| Side Slopes | 3:1 or flatter |
| Longitudinal Slope | 1.0 % min., 4.0% max. |
| Flow Depth | 1-inch for effective infiltration area calculation |
| Flow Velocity | 1.5 fps for 2-year storm |
| Length | Typically 160 to 375 ft/acre for residential areas |

# Summary of Design Criteria

- Flow Velocity < 1.5 fps for 2-year storm with critical duration equal to the time of concentration.
- Maximum velocity is based on providing adequate residence time for infiltration and preventing re-suspension. For larger design storms, velocities shall be non-erosive.

# Summary of Design Criteria

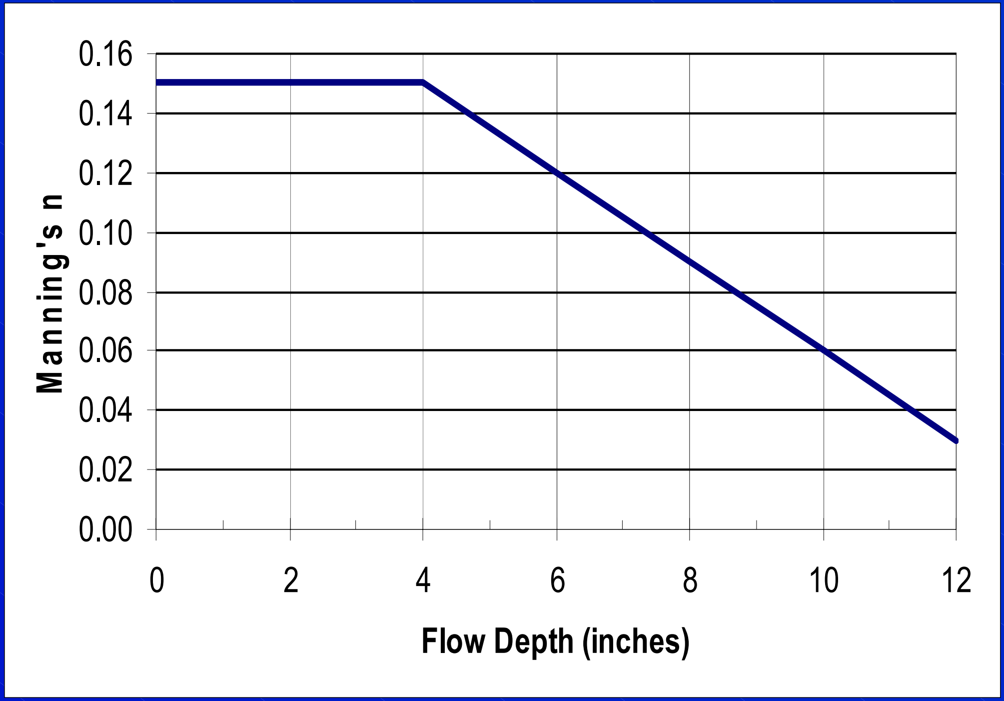
- Swales shall be planted with native vegetation (preferred) or seeded with turf grass.  Sod shall not be used due to shallow root structure and tight soils.

- To maintain vegetation, swales shall be designed to have no standing water within 24-hours after the runoff event.

# Design Considerations

## Calculation of Manning's n Value

Varies with type of vegetation and depth of flow. Typically values used are too low for flow depths and vegetation heights encountered in swale systems.




Calculating velocity Is an iterative approach.

# Design Considerations

- For steeper slopes, install check dams to reduce velocity and enhance infiltration.
- Check for downstream scour and stability.


# Construction Criteria

Minimize or mitigate the effects of compaction from grading activities with incorporation of compost into subsoil.

Stabilize as appropriate until vegetation establishes.

# Construction Criteria

Divert construction site runoff from infiltration swales until upland areas are stabilized or construct swales after site is stabilized.

# Operation and Maintenance

- Preparation of site-specific maintenance plan.
- Fertilizers use based on soil test results.  Avoid pesticide use.
- Maintain vegetation and if mowed remove dead vegetation.
- Annual inspections.

***Questions ?***